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Abstract

SHIPPING CASKS FOR THE BR2 AND HFR RESEARCH REACTORS

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The shipment of irradiated fuel elements raises many problems for the following reasons. On the one hand the technique involved is recent and the calculation, construction and testing methods and procedures are not all already sanctioned by experience and are still subject to improvement. On the other hand, the design must comply with the relatively severe criteria prescribed by the official pertinent regulations, some of which are still in course of elaboration or subject to subsequent modifications. The main purpose of these regulations is the protection of the public against radiation hazards.

The study of casks for the shipment of spent fuel elements from the BR2 and HFR research reactors, performed by BEN and BEI under contract and in co-operation with Euratom, is described. The HFR cask has already received USAEC approval and is on the point of being accepted by the competent Authority of the United Kingdom; the BR2 cask, designed according to the same principles, is now under examination.

The paper summarises the solutions selected to solve the various theoretical and technological problems to comply, under normal and accidental transport conditions, with the safety requirements prescribed by the new regu-

lations in force, mainly the AEC 10 CFR Part 72 and AIEA regulations.

A description including drawings is given. The technological fabrication problems and the design features and layout selected to ensure the mechanical resistance, the handling, the anchorage, the structural integrity and the shielding are reviewed.

Each cask contains an amount of fuel elements which exceeds the critical number. A solid stainless steel basket, which acts as neutron poison, is used to fulfill the subcriticality requirements. It allows easier decontamination, may be considered as indestructible in the accidental conditions contemplated and acts as internal heat transfer medium in the absence of water coolant.

The problem of residual heat removal, to maintain enough safety margin below the fuel element failure temperature, is investigated from a theoretical point of view. The internal primary coolant is either water or air, and fins are provided for external cooling.

The cask resistance to fire is investigated from the following points of view: critical temperatures, mechanical resistance and shielding effectiveness. A fire protection frame with insulating walls has been devised. This frame, which surrounds each cask, is also useful as shock absorbing and anchoring structure.



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Abstract

**RADIOLYTICAL AND HEAT TRANSFER PROPERTIES OF SOME
ORGANIC COOLANT-MODERATORS**

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Investigations performed in view of selecting the best types and the ways of improving the heat transfer properties of organics for reactor coolant-moderators are reported.

The organics investigated with above aim are of the hydrocarbon type. In the course of present work, among others, the most important physico-chemical features of the eutectic 28% diphenyl in diphenyl-methane mixture (D-DM) have been determined. The main attraction of this system for coolant-moderator purposes is its low melting point (13°C).

The static radiation tests were carried out in the 2 MW thermal VVRS-type nuclear reactor by irradiating samples in quartz ampoules. The radiation effects on D-DM (physical property changes, rates of gas evolution and polymerization, nature of the reaction products, etc.) were studied, in addition, in an in-pile circulating loop under similar to reactor operating conditions at various temperatures. The loop is actually a Field type tube and a canned rotor pump set-up installed vertically into the reactor core. About 8 litres of the coolant under investigation are circulated in the equipment with one litre within the reactor core. The liquid is brought to the desired temperature by an additional electric heating to the nuclear heating from the reactor. The total radiation energy input in the system was determined by calorimetry and the relative neutron dose rate was calculated from the measured values of the fast neutron flux by making use of the known energy spectrum. The thermal destruction rates were also determined.

Experiments on diphenyl-diphenyl-methane mixtures of various compositions did not reveal any appreciable energy transfer in the system.

The radiolytic decomposition rate for alkyl diphenyls was found to increase with the length of the alkyl side chain.

The experimental results show the D-DM mixture to be preferable to the polyphenyls owing to its low melting point and to be less sensitive to radiolysis than the mono-isopropyl-diphenyl.

Some thermophysical parameters of D-DM in a wide range of temperatures as well as the convective heat transfer coefficient of the system were also determined.

The convective and surface boiling transfer properties were studied on diphenyl, D-DM, and diphenyl-diphenyl-oxide systems. For these experiments the coolants were passed through a 0.5 mm long, 20 by 20 mm diameter tube containing the a.c. heated element made of stainless steel with 8 mm diameter. The effects of flow rate, subcooling and temperature (pressure) on surface boiling transfer were studied. The critical thermal load of the organic coolants under investigations was established at 260 - 400°C temperature, 1.5-6 m/sec velocity and for subcooling from 10 - 200°C.



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**INVESTIGATIONS CONCERNING THE PROCESSING OF
HUNGARIAN URANIUM ORES**

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Results achieved these last five years by research activities on problems in the processing of uranium ores are reported.

I. Mineralization and Deposition Studies

The mineralization of uranium is a rather frequent process in the sediments of continental rivers and the facies conditions of this type of depositions have been investigated in detail. It is found that the water getting into the loose sediments along the river banks with floods and in the form of underground water can be made first of all responsible for the primary enrichment in uranium. Diagenetic and epigenetic variations play an important part in the formation of the mineral grains. These results can be utilized in establishing the genesis of other deposits too.

**II. Weight Correction Radiometers and Optimum Grain Size
for Radiometric Recovery Procedures**

The physical principles involved in the methods for weight correction based on photo effect and induction

are discussed and the radiometers incorporating these principles are described. The procedure so developed permits to reduce the number of grain size fractions processed by radiometry and improves the recovery efficiency.

Experimental investigations of blasting and processing techniques in view of obtaining the optimum grain size for radiometric sorting are described. The application of the laboratory results on a production scale is illustrated.

III. Reduction of Loss due to Leaching for Uranium Ores with Carbonate Content

In sulfuric acid leaching of uranium ores containing also carbonates calcium sulphate is coprecipitated with uranium from the liquid phase. This loss in uranium recovery can be prevented by reducing first the carbonate content of the ore in a flotation process. The product which upon flotation contains the carbonate can be efficiently processed by alkaline leaching. The product containing less carbonate is then processed by sulfuric acid leaching. The two kinds of leaching considerably increase the amount recovered as compared with the merely sulfuric acid leaching of such ores. The cost of chemicals is also reduced. In the carbonate separation process it was found that the loss in U due to adsorption is caused by the decomposition of the carbonate complex.

IV. Extraction from Elutes

Some extractants or such mixtures which seemed promising for the purification of solutions eluted from ion exchange resins have been investigated. The extraction isotherms and the effects of ions in the liquid phase /sulphate, chloride, hydrochloric acid etc./ on the extraction rate were determined. The optimum conditions for the extraction were established. A possible reextraction from the organic phase was studied.

In laboratory experiments the mixtures di-2-ethyl-hexyl phosphate and tri-butyl phosphate as well as di-capryl phosphate and tri-capryl phosphate were found to be satisfactory extractants. For reextraction ammonium carbonate solution proved to be the most convenient.

Considering the problem of mixed solvents the synergetic and antagonistic effects manifesting themselves in organic solvent extraction are discussed. In these experiments di-alkyl and tri-alkyl phosphates as well as beta diketone and di-alkyl phosphate mixtures were used. The structures and some physico-chemical properties of these uranium-organic complexes were determined.

V. Structural Investigations of Ammonium Uranates and Uranium Oxide Hydrates

A several step gravitation type mixer-settler equipment has been built for the purpose of laboratory extraction.

This device is used for the production of reactor grade uranium compounds from inland uranium concentrates by means of the usual TBP treatment.

Laboratory investigations were carried out to establish how the composition and physical properties of the products are being affected by the conditions under which the precipitations and calcinations of ammonium uranates occur.

Basic investigations concerning the structure and thermal decomposition of ammonium uranates and uranium(VI)/oxyhydrates were carried out. Formation, composition and thermochemical properties of the $\text{UO}_2/\text{NO}_3/2\text{-NH}_3$, $\text{UO}_3\text{-H}_2\text{O}$ and $\text{UO}_3\text{-H}_2\text{O-NH}_3$ systems were studied. New relationships between the structures and thermal decomposition of uranium tri-oxide hydrates and ammonium uranates were established from infrared and differential thermoanalytical investigations.



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Abstract

**FIVE YEARS' EXPERIENCE WITH THE HUNGARIAN
VVR-S-TYPE REACTOR**

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The 2 MW /thermal/ VVR-S type research reactor operated at Budapest went critical the first time on March 25, 1959. It has been used since then for the study of problems in reactor and nuclear physics, solid state physics and nuclear chemistry as well as for the routine production of radioisotopes.

Since the start each of the horizontal channels of the reactor has been fully exploited for intensive research centered mainly to investigations as

- 1/ Physics of nuclear fission
- 2/ Angular correlation in /n,gamma/ reactions
- 3/ Isomeric cross sections for /n,gamma/ reactions
- 4/ Radiation effects on transformation processes in alloys
- 5/ Critical magnetic scattering of neutrons
- 6/ Neutron diffraction experiments
- 7/ Cold neutron experiments on ferromagnets
- 8/ Integral neutron scattering cross section of organics.

The vertical channels of the reactor have been used
for

- 1/ Isotope production
- 2/ Radiochemical research

- 3/ Activation analysis
- 4/ Radiation chemical research
- 5/ Irradiation for industrial and agricultural research purposes.

The production of radioisotopes started in 1960 and covered in 1963 already 50 different preparations on the production schedule. The number of aluminum target holders for the samples to be irradiated increased from 200 in 1960 to 1000 in 1963. The most economical items proved to be the short and medium lived isotopes.

In 1963 an in-pile loop with additional electrical heating element was built for investigating the radiolytic behaviour of organics seeming to be useful reactor coolant-moderators. The experimental loop has been operated without breakdown for 1000 hours within the core. Useful information has been obtained by the loop experiment on the decomposition rate of some organics under continued and simultaneous exposure to radiation and high temperature. The operation of the in-pile device did not interfere in any way with the other research activities or the isotope production going on simultaneously with the use of the reactor.

The operation time of the reactor from March 25, 1959 to December 31, 1963 amounted to 22 8000 MWhours. The refuelling required for the compensation for burn-up and poisoning amounted to 2560 gr U^{235} .

The breakdowns leading to standstill were due to

failure in the mains supply network /9 standstills,
total loss 15 hours/

failure in mechanical facilities /7 standstills,
total loss 46 hours/

failure in instrumentation /6 standstills, total
loss 7 hours/.

Total loss in operation time 68 hours, that is
5,9 % of the total number of hours the reactor has been
operating.

No breakdown was due to any fault of the servicing
personnel.

The technical facilities incorporated in or
accessory to the reactor have been modified or replaced
in several instances to meet special requirements or to
be improved on basis of operational experience.

The reactor staff servicing reactor operation and
in charge of the maintenance work has taken part, in ad-
dition, in the design, building and setting up of ap-
paratus required for individual experimental research
activities carried out with the use of the reactor. The
reactor is attended to in three shifts by 5 persons per
shift. The whole staff is regularly trained professional-
ly and kept informed of the progress in the relevant
field.